CHAPTER 1

TRAFFIC SIGNAL INSTALLATION

Introduction

The field of Traffic Signal Installation has been one of the most rapidly changing areas of highway construction. The state of the art technology has been changing so fast in the past few years that our written procedures and instructions have not been able to keep up with these changes. In this chapter the construction of a traffic signal system will be broken down into its component parts, so that each part may be discussed separately.

A technician working on a traffic signal must be aware that work activities progress very quickly, and any unresolved problems quickly become the controlling operation for the completion of the work. For this reason, the technician must do his homework by anticipating problems before they become the controlling operation. The following steps are recommended before any work is started by the Contractor:

- Review Sections 805, 806, and 912.15 of the current Standard Specifications, Section "C" of the current edition of the Manual Of Uniform Traffic Control Devices, and the appropriate Standard Sheets.
- Closely examine the plans and field check the planned locations of all structures before the preconstruction conference. These include the controller, poles, pole anchors, detector housings, loops, handholes, and signal head locations.
- Check the R/W distances as shown on the plans. This may usually be accomplished by reviewing "old road plans" held by the District Development Department.
- After the locations of all underground utilities have been determined, again closely examine the structure locations and signal cable quantities for any conflicts. Any resulting changes outside the allowable limits of the contract specifications or utility codes should be brought to the attention of your Project Engineer, Area Engineer or District Traffic Department.
- In urban areas check with property owners about possible basements extending out under sidewalk areas.

Wooden Poles With Down Guys

Wooden poles with down guys are generally less expensive to install than steel strain poles and are not preferred by INDOT. When laying out and inspecting the locations where wooden poles and anchors are being installed, the following items need to be considered:

- Each wooden pole must be visually inspected, and meet the requirements of section 913.15 (e) 2 of the specifications
- Visibly stake the locations of the wooden poles so they may be seen from any of the other pole locations.

- Avoid placing wooden poles or down guy anchors in the ditch line.
- Wooden poles are set a minimum of 7 feet in the ground and raked back out of plumb 12 inches. Observe the material excavated from the hole for possible utility conflicts.
- For single spans the pole anchors are located by extending the line of the span back 20 feet from the pole and swing a 7.5 feet arc in either direction.
- For double spans the pole anchors are located by extending the line which divides the extension of the two spans back 20 feet and swing a 7.5 feet arc in either direction.
- Any pole anchor location change which would place the pole anchor closer than 15 feet from the wooden pole should generally not be permitted. The use of a strain pole should be investigated for cases of insufficient anchorage.
- The line on the drilled hole for the pole anchor should be toward the top of the wooden pole.
- The breaking of the expansion anchor and the proper backfill and compaction of the anchor assembly are critical to the proper functioning of the wooden pole. Initial and continued movement of the anchor assembly need to be monitored.

Steel Strain Poles

Steel strain poles are used primarily on urban intersections. Steel strain poles have a much higher initial installation cost, but the service life is also much longer than a wooden pole with down guys. When laying out and inspecting the locations where steel strain poles are being installed, the following items need to be considered:

- The Basis For Approval for the #4 and #10 bars in the foundation will be the sequence number from a laboratory report unless they are from an approved list. The Basis For Approval for the concrete will be the sequence number reported on the IT-652. The Basis For Approval for the steel strain pole and the anchor bolts will be a Type C Certification.
- The footing dimensions are 3 feet in diameter and 12 feet deep.
- If bed rock, or loose stones or boulders more than 1/2 of a cubic yard in volume are encountered before the 12 foot depth is obtained, immediately contact your PE/PS or Area Engineer. Section 206.02(b) Class X Excavation covers the procedure to be taken if this occurs.
- The contractor always has the option of using a foundation casing, if unstable soil conditions are anticipated.
- The exposed portion of the foundation may be 3' in diameter or 3' square.
- Adjacent anchor bolts should be oriented in the same direction with the span or spans attached to the steel strain pole.

BASE OF A STEEL STRAIN POLE SHOWING FOUNDATION, BOLTS AND EXPOSED PORTION OF FOUNDATION. NOTE THE GAVANIZED SHIELD AND A FULL THREAD IS EXPOSED ON THE BOLT AFTER TIGHTENING THE NUT.

- A tremie will be used until the concrete is within 5 feet of the top of the foundation.
- The steel strain pole foundation will be finished 4 to 6 inches above the original ground and the top edge will be chamfered. In locations where the foundation is located within the sidewalk, the sidewalk elevation will be the top of the foundation.
- Each foundation will have a minimum of three (3) conduit entries with grounding bushings.
- Each steel strain pole will be grounded by a continuous #6 bare copper wire from the grounding lug on the inside of the steel strain pole through the conduit grounding bushings and grounding duct to an 8' x 1/2" ground rod located one (1) foot away from the foundation and one (1) foot below the finished ground surface.
- The exposed concrete surface of the foundation will be rubbed after the forms are removed.
- The steel strain pole should be raked back 12 inches away from each span.
- If electrical service is on the steel strain pole, run all three conduits from the steel strain pole to the controller. Check with District Traffic possible future designs.
- If a handhole is located within approximately 10 feet of a steel strain pole foundation on a corner other than the controller corner, run one of the spare conduits to that handhole for future use.

Span, Catenary and Down Guys

The span and catenary are one of the first things that a motorist will notice about a signalized intersection. If the span and catenary are sagging or look sloppy, the whole job looks bad.

When inspecting the installation of spans, catenaries, and down guys, the following items need to be considered.

- The Basis For Approval for 3/8" or 1/4" stainless steel aircraft cable is a Type C Certification.
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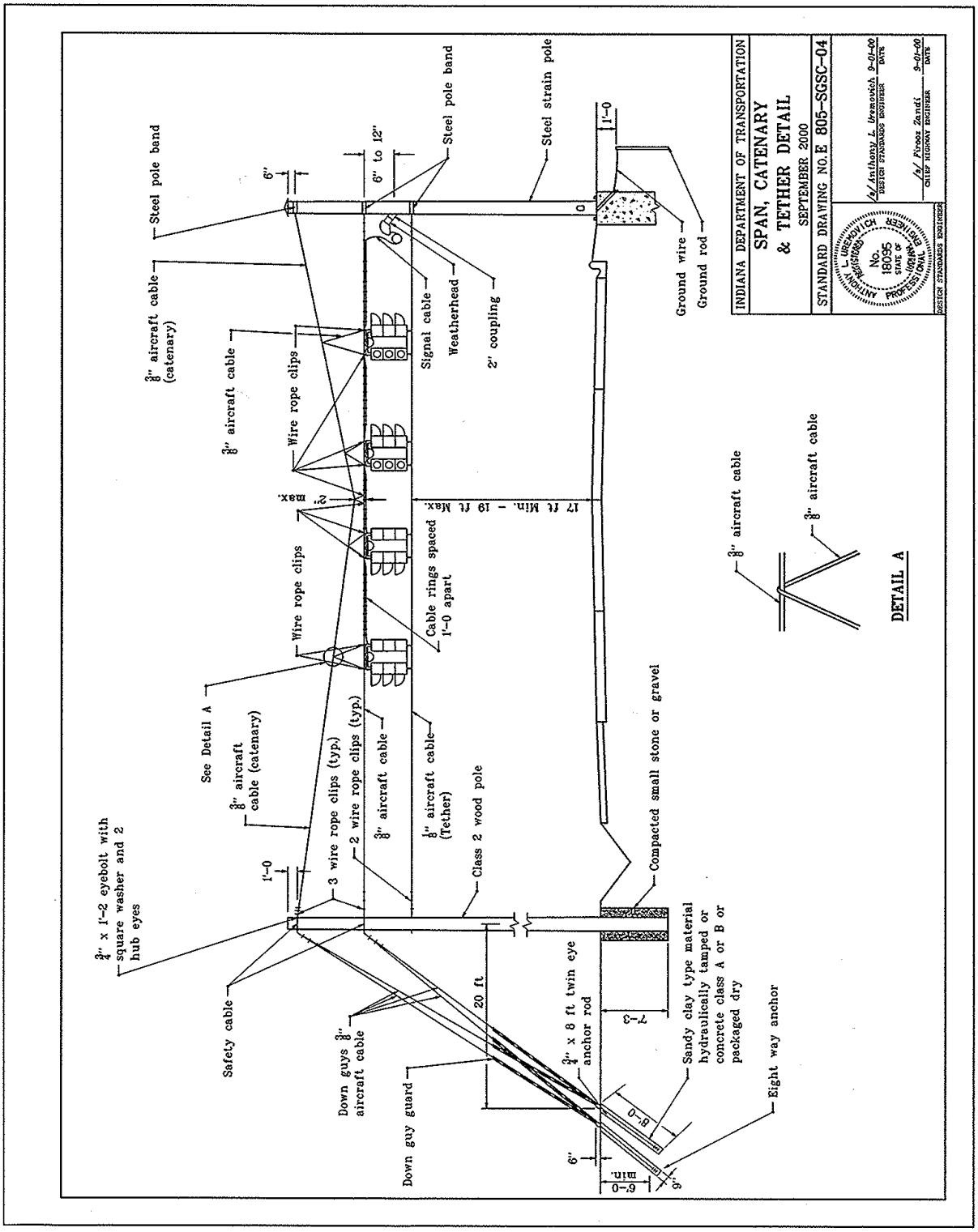
- Spans, catenaries, and down guys will be 3/8" stainless steel aircraft cable, and "A" wires may be 1/4" wire rope or 3/8" aircraft cable. Tether lines are generally 1/8″ aircraft cable.
- It is generally desirable to have the spans level. Therefore, a leveling mark should be placed on the side of each pole representing the pavement elevation at the lowest signal head.
- Assume a mounting height of 18 feet to the bottom of the lowest signal head, and 4 feet from the span to the bottom of a three section signal head or 5 feet from the span to the bottom of a four or five section signal head.
- The span is located by measuring 22 or 23 feet from the leveling mark for the location of the drilled hole for the wooded pole or pole band for the steel strain pole.
- The catenary is located a minimum of 12 inches below the top of either a wooden pole of steel strain pole. The catenary connection may have to be lower depending on overhead utility conflicts.
- Three (3) Crosby clamps will be used at each eye bolt or pole band connection and shall be installed in alternate directions. Three bolt clamps are never used on aircraft cable.
- The aircraft cable will be doubled back 54 inches at each eye bolt or pole band connection. The first Crosby clamp shall be installed 3" from the eye bolt, the second 18" from the first, and the third 18" from the second.
- Downguys must be in place before any work is performed on the spans and catenaries of wooden poles.
- The downguys should be tightened until the top of the wooden pole starts to move.
- A span jack is used to tighten the spans. For double spans, each span is jacked alternately until each is banjo tight.
- The catenary swinging free should be between 18 and 24 inches above the span at the closest point.
- The span and catenary should be connected at the center of the span. The signal heads will be supported and leveled from the catenary by means of "A" wires. Each "A" wire will be connected at the bottom by two Crosby clamps spaced 12 to 24 inches apart. No Crosby clamp will be used at the top of the "A" wire. The ends of the "A" wires will be protected by servi-clips. "A" wires may be either 1/4" or 3/8" aircraft cable.

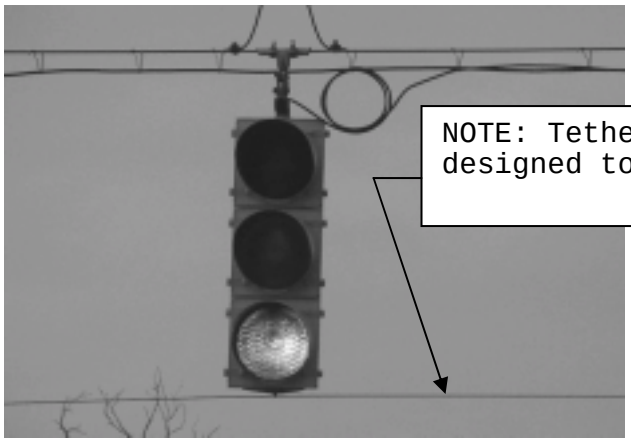
- The National Electrical Code requires 8 feet vertical and 6 feet horizontal clearance from any overhead primary conductor.



Signal Head Installation and Clearances

The traffic signal heads are in most cases the only part of the whole traffic signal system that the motorist actually sees. Therefore the vertical and horizontal positioning and the directional orientation are critical to a well functioning system. When inspecting the installation of traffic signal heads, the following items need to be considered:

- The Basis For Approval for signal heads and accessories is a Type C Certification.
- Inspect each signal head assembly while still on the ground for the following:
  - Physical defects.
  - Visor type.
  - Bulb sizes.
  - Lens orientation.
  - Wiring specifications.
  - Too much play between the balance adjustor and weatherhead clevis.
  - Approximate vertical hanging for each signal head

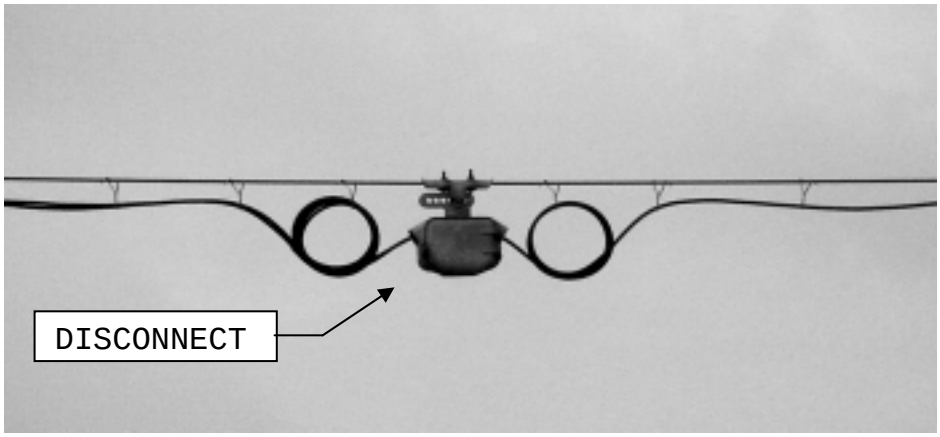


- Signal head clearances will be between 17 feet and 19 feet.
- Signal heads will be adjusted vertically to approximate a uniform grade of all like signal heads.
- Signal heads will be located and aimed according to the plans. The minimum spacing between signal heads serving the same direction is 8 feet. The minimum spacing between free swinging signal heads not serving the same direction is 4 feet. The district traffic department should approve the layout of signal heads.
- If a tether line is specified, all the signal heads need to be aligned vertically. This may have to be done several times if the span or catenary requires adjustment.
- If a signal head needs to be mounted more than 2 hours before its use than the entire signal head must be hooded.
- Hooded signal heads are not to be left up for more than five days.

Disconnect Hanger Installation

The disconnect hanger is an electrical junction box generally suspended by itself at a specified location on the span, and all the wiring connections are performed while on the span. When inspecting the installation of a disconnect hanger the technician needs to consider the following items:

- The Basis For Approval for disconnect hangers in a Type C Certification.
- Inspect each disconnect hanger while on the ground for the following:
  - Physical defects.
  - Tightness of door latch and span hanging connections.
  - An 18 circuit terminal block.



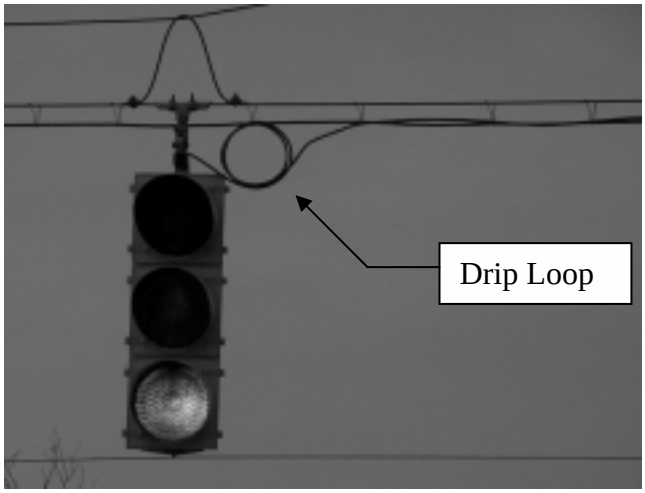
Traffic Signal Cable Installation

Traffic signal cable is the multi-conductor cables which carry electrical impulses from the power source to the entrance switch, from the entrance switch to the controller, from the controller to the signal heads, and from the controller to the detection devices. Pay items are designated by the number of conductors in the cable and the gauge of the cable. When inspecting the installation of traffic signal cable, the technician needs to consider the following items:

- The Basis For Approval for all traffic signal cable is a Type C Certification.
- The color coding scheme should be discussed at the pre-construction conference and should conform to the district policy.
- Fused and unfused cables shall not occupy the same conduit. 3C/8 traffic signal cable is considered unfused.
- The only acceptable underground splice in a handhole is a poured epoxy splice.
- In above ground pole handholes, an acceptable splice is a "standing splice" utilizing wire nuts and electrical tape wrapping.
- For traffic signal cable hung from a span, cable rings will be spaced at 12 inches.
- Traffic signal cable quantities need to be verified. However, plan quantity will be paid if the measured quantity is within ± 25% of planned quantity.

Drip Loop Installation

The purpose of a drip loop is to prevent water from entering the weatherhead at either a signal head, disconnect hanger, or traffic pole. Drip loops should be approximately 6 inches in diameter, contain at least one full turn of traffic signal cable and be wrapped tightly with several wraps of electrical tape. The drip loop should not rub against the traffic signal head.

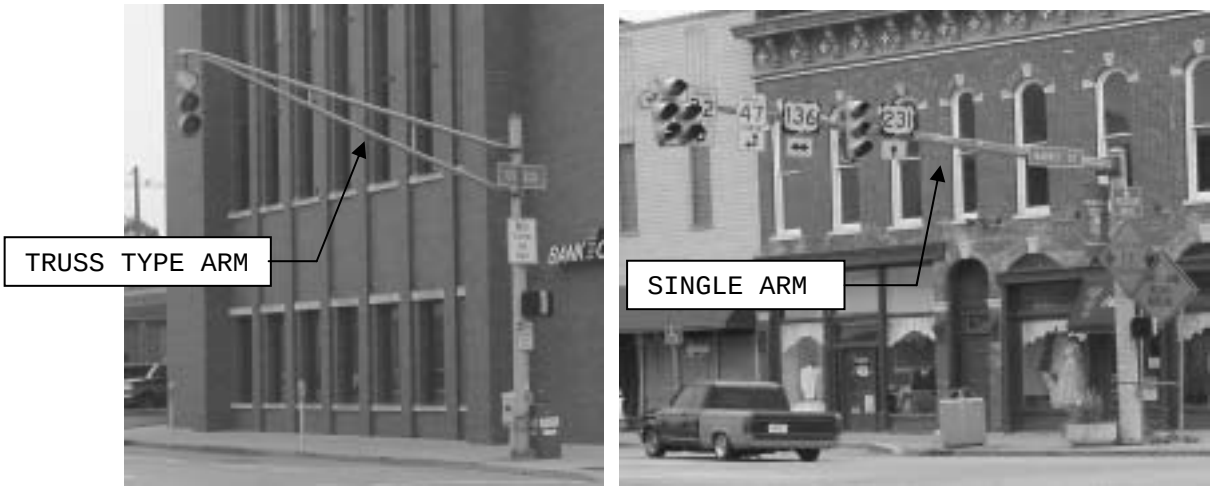


Pole And Mast Arm Installation

Pole and mast arm installations are found in urban areas, where spans and catenaries are either impractical or not as esthetically pleasing as poles and mast arms. When inspecting the installation of a pole and mast arm system, the following items need to be considered:

- The Basis For Approval for the pole, mast arm, anchor bolts and accessories is a Type C Certification. The Basis For Approval for the concrete used in the footing is the sequence number reported on the IT-652.
- Field check each footing location using the planned mast arm length and locate the end span signal head according to the plans. Any apparent errors in the plans need to be brought to the attention of your PE/PS or Area Engineer immediately.
- Check the R/W distances as shown on the plans to be sure that the footing is entirely within the R/W.
- After the underground utilities have been located, check to insure that the footing locations meet the following criteria:
  - The face of the pole must be at least 18” from the face of the curb.
  - Underground utility clearance requirements must be satisfied. Encasement of an underground utility should never be considered without prior consent of that utility company. Unexpected or mismarked underground utilities are one of the largest causes of contract delay.
  - Do not locate a footing within the confines of a wheel chair ramp, or in such a location where a wheel chair would have difficulty maneuvering. If the foundation is required to be in the curb ramp area then move the foundation as far out of the ramp as possible and place the top of the foundation level with the curb ramp grade.

    - If Walk-Don't Walk indications are specified, they must be clearly visible from the beginning of the crosswalk to within ten feet of the opposite side. This means trying to keep the footing as close to the crosswalk lines as possible.
    - The footings should be located so that the signal heads are between 40 and 120 feet from the stop bar.
    - The location of the footing may be moved a maximum of two feet perpendicular to flow of traffic, but the mid-mast signal head should still be located at a lane width spacing from the end mast arm signal head. The mid-mast signal head should never be located beyond the curb line and the minimum spacing between signal heads is eight feet.
- If possible, locate the footing entirely off the sidewalk.
- Each footing will have a minimum of three conduit entries.
- Each mast arm pole will be grounded by a continuous #6 bare copper wire from the grounding lug on the inside of the mast arm pole through the conduit grounding bushings and grounding duct to an 8' X 1/2" ground rod located one (1) foot away from the foundation and one (1) foot below the finished ground surface.
- If the footing is greater than five feet deep, a tremie is required below the five foot level.
- If the footing is located in a sidewalk area, it will be finished flush with the surrounding sidewalk. If the footing is located in a non-sidewalk area, it will be finished 4 inches above the original ground using chamfered edges around the top of the footing.
- Expansion joint material will be used when the footing comes in contact with any other concrete.
- The Walk-Don't Walk indications should be located on the pole in such a manner as to provide protection from truck turning movements.
- The bottom of the mid-mast mounted signal head should be adjusted level with the end of the mast arm signal head.



POLE & MAST ARM

Electrical Service And Entrance Switch Installation

The electric service requirements vary with the utility company involved. Generally speaking, if the electric service does not meet any of the requirements of that utility company, the electricity will not be hooked up. When inspecting the installation of an electric service the following items need to be considered:

- The Basis For Approval for the entrance switch, the conduit riser, the weatherhead, the traffic signal cable and all other miscellaneous material is a Type C Certification.
- 3C/8 (3 conductor, 8 gage wire) stranded traffic signal cable will be used for the electrical service from the service weatherhead to the entrance switch, and from the entrance switch to the controller.
- Leave at least 4 feet of 3C/8 rolled up at the weatherhead.
- An electric meter will be place above the entrance switch if required by the local power company, or if specified by the INDOT.
- Since the controller operates on 120 volts, one conductor of the 3C/8 will be terminated at the entrance switch.
- For an electric service on a steel strain pole, a 1 inch riser with weatherhead will be placed on the outside of the steel strain pole. Conduit hangers are banded to the outside of the steel strain pole and the conduit in installed on the hangers.
- An oxidation inhibitor shall be applied to all surfaces that mate with a dissimilar material such as aluminum to steel.
- Conduit straps or hangers will be placed 1 foot from the weatherhead and at a maximum spacing of 5 feet from there down.
- Entrance switch enclosures will contain a single pole 50 amp breaker.
- The bottom of the entrance switch will be mounted at a height of 4 feet.
- The entrance switch will be grounded by means of a #6 bare solid copper wire encased in a 1/2 inch electrical conduit between the entrance switch and the ground rod.
- The 8' X 1/2" ground rod will be located 1 foot outside the pole or foundation and 1 foot below the ground surface. The grounding connection will be an approved type.

ELECTRICAL SERVICE & ENTRANCE SWITCH

Controller Installation Including Foundation

The traffic signal controller is the mechanism which makes the traffic signal system operate the way it was intended. For the purposes of this course, the controller will be treated as a "black box", and the operation of the controller will not be covered in much detail. The technician should never change any of the settings of any of the equipment inside the controller cabinet. Only a trained District Traffic Signal Technician has the authority to set or change any of the various controller timings. When inspecting the installation of a traffic signal controller, the following items need to be considered:

- The Basis For Approval for the concrete used in the foundation is the sequence number from the IT-652. The Basis For Approval for the controller, the cabinet and all accessory items is a Type C Certification and an approval number from a list of approved materials issued by the Division of Materials and Tests.
- The controller cabinet should be in the same direction oriented so that a traffic signal technician standing at the controller with the door open can see the majority of the signal heads.
- Always try to anticipate any future maintenance problems you might be creating.
- Check the plans and standard sheets for the controller foundation location, type, dimensions, and anchor bolt placement.
- There will be a minimum of three conduit entries into the controller foundation. There should always be a spare conduit entry. The price of a few extra feet of conduit is cheap compared to the price of relocating the controller foundation on a future modernization contract.

- The top edges of the controller foundation will have chamfered edges, and the exposed sides of the foundation will be rubbed.
- Controller "A" bases in non-sidewalk areas will be finished 4 inches above the finished ground level and the top edges will be chamfered. Controller "A" bases placed in sidewalk areas will be finished flush with the surrounding sidewalk.

- The top of the controller foundation needs to be sloped toward the controller drain.
- A continuous run of #6 bare copper wire will connect the grounding lug on the controller back panel, each conduit grounding lug, and the approved grounding connection to the ground rod.
- An 8' X 1/2" ground rod will be placed one foot outside the confines of the controller foundation, and one foot below the finished ground level.
- The controller cabinet door should open and close easily when the controller cabinet is properly aligned on the controller foundation, and the outside lower edges of the controller will be sealed all around with a silicone sealer.

- All field wiring shall be neat and easy to follow. The "bird nest" affect should be discouraged.
- All traffic signal cables entering the controller cabinet, signal poles, and handholes will be tagged with aluminum tags indicating the signal phase, pedestrian phase, power, pedestrian actuation, or loop phase.
- On traffic signal modernization contracts, the old and the new systems should be kept independent of each other at all times.
- A District Traffic Technician will always be present when a new signal system is turned on for the first time.
- Newspapers, TV and radio stations, schools, and law enforcement agencies should be notified of the new signal turn on dates.
- A new traffic signal system at an intersection where a traffic signal system did not exist beforehand or where a flashing beacon system is being upgraded to a traffic signal system shall remain on flash for at least three days prior to placement on normal operation. A new signal should never be placed on normal operation on a Friday or just before a holiday.

A partially completed IC-636A should be sent to the District Traffic Office indicating the signal turn-on date and time.

Steel Conduit Installation

Steel conduit is used to carry the traffic signal cable between the controller and all points of intended use. When inspecting the installation of conduit, the following items need to be considered:

- The Basis For Approval for conduit is a Type C Certification.
- Steel conduit shall be 2 inch nominal diameter.
- Rigid grade and intermediate grade steel conduit are both acceptable. Most contractors elect to push rigid conduit.
- PVC conduit is also acceptable, but the 12 inch cover of B-borrow makes it financially unattractive to most contractors. PVC conduit also requires 2 inches of B-borrow under the conduit.
- Steel conduit shall be installed to a depth of no less than 24 inches below the finished grade, unless otherwise indicated.
- The maximum length for a straight run of conduit between handholes is approximately 250 feet. This figure could be considerably less depending on the number of bends in the run of conduit.
- All conduit inside a foundation is included in the price of the foundation.
- Pushed or jacked conduit is the most expensive conduit for the contractor. Pushing or jacking methods should not create an excessive void around the conduit, and the jacking pit shall be kept a minimum of 2 feet from the nearest pavement or shoulder.
- The edges of all street cuts for detector housings or looking for stopped jacked conduit shall be sawed.
- Compacted B-borrow shall be used for the backfill of all street cuts not at a detector housing.
- Except at detector housings, street patches will match the surrounding pavement. 12 inches of concrete and 1 to 2 inches of bituminous surface mix is an acceptable patch for asphalt pavement.

Handhole Installation

Handholes are junction points for conduit and pulling points for the traffic signal cables in these conduits. Handholes should be placed as near as possible to the locations as shown on the plans. When inspecting the installation of handholes, the following items need to be considered:

- The Basis For Approval of the handhole tile is an approval number (P number) stenciled on the side of the tile. The Basis For Approval of the handhole ring and cover is a Type C Certification.
- Handholes shall be class III reinforced concrete pipe and be constructed per standard 805 SGCF-04. Handhole tiles with pre-poured concrete bases are not approved for INDOT use.

- Handholes should be placed in the direct line of the conduit run, if possible.
- 250 feet is the maximum handhole spacing for a straight run of conduit.
- A handhole should not be placed in a ditch line.
- A handhole should be located to alleviate any possible water standing in a conduit, and to prevent any water from backing up into the controller cabinet.
- The grade of the ring and cover should match the existing grade.

HANDHOLE INSTALLED FLUSH WITH SURROUNDING GROUND

- 12 inches of pea sized or larger gravel will be used under the bottom of the handhole unless the parent material is granular.
- Concrete for the 5 inch pad should be worked under the handhole tile. Concrete for the 5 inch pad may be either class "A", "B", "C", or bag mix conforming to ASTM C-387.
- Conduits should extend 3 to 6 inches beyond the inside wall of the handhole tile, and be grouted. Grout mix shall conform to ASTM C-387.
- All conduits shall have bushings.
- All traffic signal cable shall have approximately 2 feet of slack in a handhole.

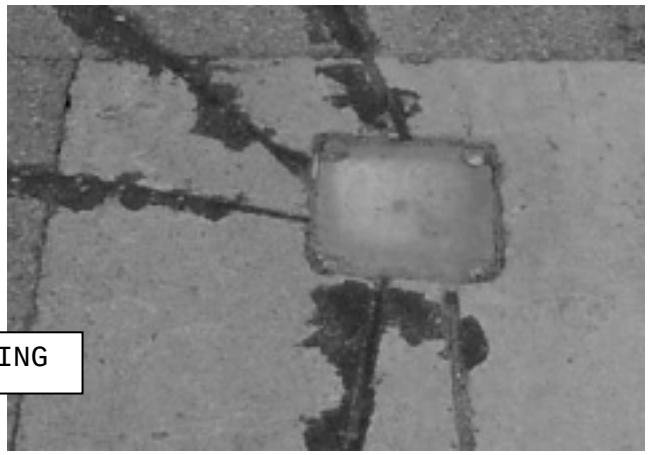
Detector Housing And Traffic Detection Loop Installation

Properly installed detector housings and traffic detection loops are critical to the intended functioning and the expected service life of the detection system. The technician needs to know what to look for to avoid potential failures in the detection system in the future. When inspecting the installation of detector housings and traffic detection loops, the following items need to be considered:

Detector Housing Installation

- The Basis For Approval for the concrete used in the detector housings is the sequence number from the IT-652. The Basis For Approval for the aluminum detector housing, the 1C/14 loop wire, and loop sealant is a Type C Certification.

- The detector housings, traffic detection loop corners, and the stop bars must first be laid out according to the plans.
- If at all possible, avoid crossing a working joint or working crack with a loop wire. Moving the location of a detector housing or traffic detection loop 2 or 3 feet to avoid crossing a working joint or crack is acceptable. A detector housing may be butted up against a contraction joint.
- If the side of a loop runs parallel to a joint or crack, at least one foot of clearance needs to be maintained between the loop and the joint or crack.
- Observe traffic flow for drivers' habits, incidents of false calls, drivers overrunning the loops, or stopping too soon to be detected by the loops. If a major change in the location or number of loops is required, contact your Area Engineer or District Traffic Office before making such a change.
- Detector housings should generally be placed inside the pavement, but should not be located where water is likely to stand, such as in a gutter line.



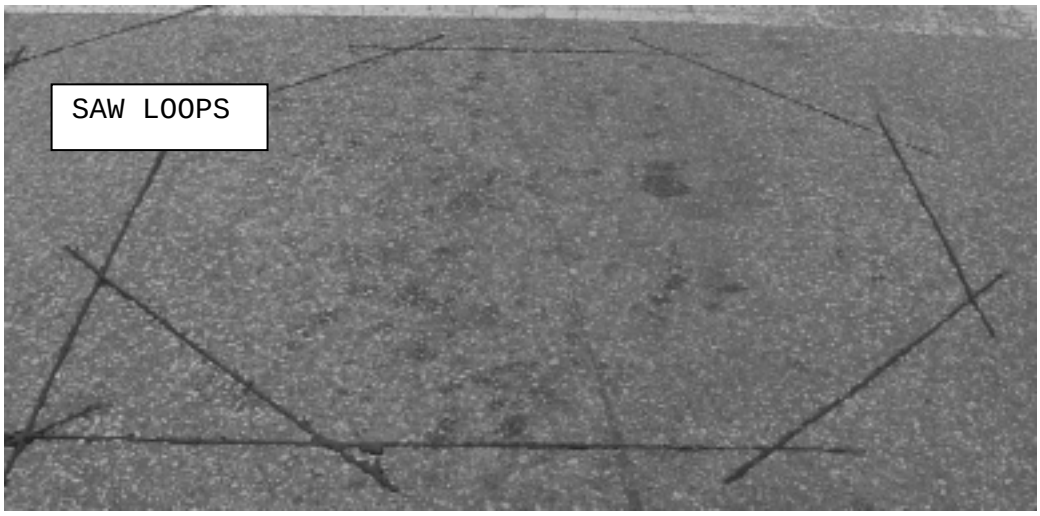
DETECTOR HOUSING

- Galvanized steel elbows shall be used in the detector housings.
- Detector housings poured in pavement under traffic shall be poured using high early strength concrete. The high early strength concrete may be made with 564 pounds per cubic yard of type III or type IIIA portland cement concrete mix design, or with 846 pounds per cubic yard type I or type IA portland cement concrete mix design.
- The freshly poured detector housing shall be covered with a steel plate, generally at least 3' X 3', for the cure time of the concrete (see section 702 of the Specifications).
- Bituminous cold mix around the edges of the plate works well to hold the plate in place.
- Where a portion of the road is closed, or where there is no vehicular traffic, class A concrete may be used to pour detector housings.
- Work should be scheduled so that a detector housing is poured the same day it is dug.

The aluminum detector housing and surrounding concrete base should be finished flush with the surrounding pavement, although the aluminum detector housing may be finished 1/2 inch below the surrounding pavement.

Sawing Loops

- The contractor has the option to use either wet or dry saw blades on the saw slots. However, wet blades should be discouraged in freezing weather, and dry blades should be discouraged in urban areas where air pollution standards may be violated.
- The width of a saw slot will be between 3/8" and 7/16". The minimum saw slot depth in concrete will be 3"(2″ + 1″ of cable), and in asphalt will be 3½" (2½″ + 1″ of cable).
- All loops shall be octagonal (eight sided) in shape with sides of 2'-6" in length.



- All loop locations are subject to the approval of the District Traffic Engineer, who shall be notified at least 48 hours prior to any to any loop placement.
- No more than one loop may be served by the same saw cut.
- Always saw deeper and wider when crossing a working joint or crack, and leave slack in each turn of the loop wire.
- The saw slots shall be inspected for their total length for depth requirements. The saw slots must also be totally dry before the loop wire is placed.

Installation of Loop wire

- All loops shall be wired with 4 turns unless otherwise noted.
- THW 1C/14 (one conductor 14 gage wire) wire inside a 1/4" O.D. PVC jacket is specified for loop wire.
- All loop wire shall be placed in the saw slots in a clockwise manner as viewed from above.
- Loop wires shall be pressed into the saw slots with a blunt non-metallic object.

- A 1/2" diameter X 2" backer rod spaced at 15" intervals shall be installed over the loop wire. This prevents the loop wire from floating up while the sealant is applied. The loop wire in placed on the bottom of the saw slot.
- At no time shall the loop wire be bent at angles less than 120 degrees.
- All loops are to be wired in series (the end tagged "in" of one loop attached to the end tagged "out" of the next loop) unless otherwise noted.
- The loop lead-in wires (between the loop and the detector housing) shall be twisted around each other a minimum of 5 turns per foot, tied with cable ties, and coiled in the detector housing.
- A maximum of 18" and a minimum of 12" of loop wire will be allowed in the detector housing for each loop lead-in wire.
- In the detector housing, each lead-in wire shall be tagged as either "in" or "out".
- The black wire from the 2/16 shielded cable shall be spliced to the free loop lead-in wire tagged "out", and the white wire from the 2/16 shielded cable shall be spliced to the free loop lead-in wire tagged "in".
- The Contractor shall meter each loop at the detector housing and each 2C/16 shielded cable at the controller. The technician shall witness and record each of the following test procedures:

    - Inductance in micro-henries performed at the detector housing and at the controller cabinet.
    - Resistance in ohms performed at the detector housing and at the controller cabinet.
    - Induced A.C. voltage in volts performed at the detector housing and at the controller cabinet.
    - Leakage resistance in mega-ohms performed at the controller cabinet after the splices in the detector housing have been fully submerged for two minutes in a solution containing water and one table-spoon of baking soda.
- Values for the above tests shall meet the following requirements before the loop installation shall be accepted:

    - 80 - 800 micro-henries.
    - Less than or equal to 8 ohms.
    - Less than or equal to 3 volts.
      Greater than 100 mega-ohms.
- All loop testing shall be performed at the detector housing before the loop wires have been spliced and at the controller cabinet after the loop wires have been spliced. No loop sealant shall be placed until all the loop tests have been successfully completed. It is best if the loop sealant is not placed until all the loop tests have been successfully completed.

- The vehicle simulator test shall also be required before the loops shall be accepted. The test vehicle is fabricated with an 8 foot long piece of #6 bare copper wire formed into a circle. The two ends are twisted together and the circle is drug across the loop by a non-conductive string. The loop amplifier should record a call as the circle is pulled across the loop and the call should be cancelled as the circle leaves the loop.
- The loop sealant shall be from a list of approved loop sealants issued by the Division of Materials and Tests.
- All loop splices shall be soldered and waterproofed in accordance with Standard Sheets.

Thermo-plastic, Preformed Plastic, And Epoxy Pavement Marking Installation

The locations of stop bars and cross walk lines may be dependent upon the locations of the signal heads, walk-don't walk indications, wheelchair ramps, and the traffic detection devices. The technician may have to re-read these above sections to properly locate the stop bars and cross walk line. When installing thermoplastic or preformed plastic pavement markings, the following items need to be considered:

- The Basis For Approval for thermoplastic and preformed plastic pavement markings is a Type C Certification. The Basis For Approval for 100% solids epoxy is a Type A Certification. The Basis For Approval for the glass spheres will depend upon the quantity used as set out in the current edition of the Frequency Manual.
- Check with your PS/PE or the specification for the weather limitations of each material used.
- The following design considerations are important in laying out stop bars and cross walks:
    - Common sense and observation of all traffic movements should be used in the determination of stop bar and cross walk locations. Note the stop sign location is usually not the best place to layout the stop bar (due to site distance). Check with your PS/PE, AE, or district traffic for the best location.
    - The beginning of the stop bar will be at least 40 feet from the nearest signal head and not more than 120 feet from the farthest signal head serving that direction.
    - There will be a minimum of 4 feet clearance between the stop bar and the nearest point on the cross walk line.
    - The cross walk lines will run parallel and be separated by a minimum of 6 feet.
    - Cross walk lines should proceed in a straight line from wheel chair ramp to wheel chair ramp.
    - Try to avoid crossing manhole covers or straddling any transverse joint or crack.
- The following removal of existing pavement markings will be included in the unit price for new pavement markings:
    - All incorrect and clearly visible existing stop bars and cross walk lines on asphalt pavement.

    - All existing preformed plastic pavement markings on asphalt pavement. These are generally brittle and easily dislodged at the curb line, and show sign of deformation in the wheel tracks.
    - All visible pavement markings on concrete pavement.

- Thermoplastic may be placed over existing well worn thermoplastic or well worn traffic paint.
- The pavement surface shall be dry, and at least 55 degrees F for thermoplastic and 60 degrees F for preformed plastic pavement markings.
- The application area shall be pre-stripped on all types of pavement with a manufacturer approved binder material to insure adhesion.
- Thermoplastic application temperatures will be between 400 and 450 degrees F.